

## **4 Conceptual Site Model**

Data collected during the RI, Supplemental RI and interim actions provide information necessary to understand the nature and extent of contamination and potential exposure to human health and the environment at Skykomish. This section of the FS/EIS synthesizes the available data into a conceptual model of contaminant occurrence, movement, and potential exposure. The conceptual site model presented herein is primarily qualitative in nature and serves to translate available physical, chemical, and biological data into an accurate narrative and graphical representation of site conditions. The model serves as a useful aid to the development of cleanup standards and cleanup action alternatives that are the subject of forthcoming sections of the FS/EIS.

### **4.1 Source Characterization**

There are no continuing sources of hazardous substance releases at the site. All existing contamination derives from historical releases that occurred during operation of the Former Fueling and Maintenance Facility (from 1893 to 1974). Historical releases (e.g. spills, leaks, discharges) from storage facilities and former fueling and maintenance activities are the presumed primary sources of contaminant release. A search of historical records revealed no documentation of fuel or other contaminant releases.

Figure 2-2 shows three generally contiguous source areas (Maintenance, Fueling, and Electrical Substation/Sandblasting), defined on the basis of historical records of structures and known operations. The three areas are all located east of 5<sup>th</sup> Street between the existing rail lines and the former Maloney Creek channel.

### **4.2 Indicator Hazardous Substances and Impacted Media**

The conceptual site model focuses on contamination of soil, groundwater, surface water and sediment arising from releases of metals (primarily arsenic and lead) and petroleum fuels (Table 4-1). The analysis of all hazardous constituents detected at the site (see Section 3.3) demonstrates that risks to human health and the environment are dominated by these contaminants.

In Section 5, cleanup levels are ultimately established for metals, petroleum hydrocarbons, select PAHs and the more updated IHSs detected at the site (e.g., PCBs). However, near-surface metal deposits within the railyard and the magnitude and impact of petroleum fuel releases, are the central driving force behind the development and evaluation of cleanup action alternatives presented in this FS/EIS.

With the exception of near-surface soil, the IHSs at the site are TPH and the PAH associated with the TPH residues. The TPH is relatively free of volatile contaminants (BTEX) that are common to lighter fuels (e.g., gasoline). Surface soil (0 to 2 feet bgs) is considered separately from deeper soil in this analysis because metals are found predominantly only in surface soils.

The following sections demonstrate how the IHSs listed in Table 4-1 have or have not migrated from their source.

#### **4.2.1 Metals**

The nature and extent of metals contamination at the site were described extensively in Section 3.1.1. Lead and arsenic are the only metals IHSs at the site. Moreover, soil is the only medium that contains metals above background and IHS screening levels. The distribution of metals is largely confined to the railyard where potential sources resulted from railyard operations such as coal-burning locomotives, sandblasting, use of lead-containing fuels, painting and other metal-producing activities. Consistent with these near-surface source activities, metal impacts are confined to surface and near-surface (less than 5 feet bgs) soil. Further, there are no observable groundwater impacts from these near-surface metal deposits. This suggests that dissolution of metals into surface water and infiltration of surface water to groundwater is not detrimental to groundwater quality.

Soil sampled off the railyard contained occasional and sporadic detections of lead and arsenic above background. The source(s) of this lead and arsenic is unknown.

#### **4.2.2 Total Petroleum and Polynuclear Aromatic Hydrocarbons**

The nature and extent of TPH and PAH contamination at the site were described extensively in Section 3. The source(s) of these contaminants were releases of petroleum fuels during operation of the former fueling and maintenance facilities. While these sources no longer exist, the resulting impacts to soil and groundwater quality require an assessment of exposure risks (Section 4-4) and development of cleanup standards (Section 5).

A continuing impact of the historical petroleum releases on soil and groundwater quality results from the presence of free and residual product in the subsurface. Free product (oil) discharges to the river are observed at a number of seep locations opposite the levee and west of 5<sup>th</sup> Street. The residual product (i.e., that which does not appear as a distinct separate layer or move as a separate phase under the influence of gravity and groundwater flow conditions) serves as a secondary source of petroleum hydrocarbons that dissolve in groundwater, which ultimately discharges to the river. Therefore,

knowledge of the characteristics and behavior of free and residual product and its interaction with groundwater and soil is important to understanding current site conditions.

### **4.2.3 Characteristics and Behavior of Free and Residual Product**

LNAPLs or “light nonaqueous phase liquids” can describe both free (mobile) and residual product. MTCA defines LNAPL as a “hazardous substance that is present in the soil, bedrock, groundwater or surface water as a liquid not dissolved in water.” LNAPLs derived from petroleum fuels are complex mixtures of organic (carbon-based) molecules with slight solubility in water. The term “light” refers to the density of petroleum liquids as typically being less than that of water. The term “nonaqueous” refers to the fact that petroleum liquids are not miscible with water (i.e., they do not mix with and fully dissolve in water to form a single phase). Instead, LNAPL exists as a separate phase in contact with water and soil particles. LNAPL at the Skykomish site is derived from releases of petroleum fuels (primarily diesel and bunker C fuel oil) used at the Former Fueling and Maintenance Facility.

The general character and behavior of free and residual product in the subsurface environment is illustrated on Figure 4-1. MTCA defines “free product” as LNAPL “present in the soil, bedrock, groundwater or surface water as a distinct separate layer” and “capable of migrating independent of the direction of flow of groundwater or surface water.” The figure graphically depicts contaminated and uncontaminated soil conditions. Product releases that reach the water table remain near the groundwater table because the density of the free product is less than that of water. As the water table fluctuates seasonally the free product is “smeared” vertically across the soil in the fluctuation interval. The buoyancy of product in water inhibits LNAPL migration below the seasonal low water table.

Petroleum hydrocarbons and water share soil pore space (Figure 4-1). This sharing limits product mobility and complicates its recovery from the subsurface. Released product migrates downward through the subsurface under the influence of gravity. Above the smear zone, volatile product components, where present, separate into soil gas and form vapor plumes local to the release. This is not a significant concern at the Skykomish site based on empirical data obtained from indoor air sampling during seven sampling events at six residences and structures throughout town (refer to Section 5.2.1.4 for additional discussion). Upon reaching groundwater, the product spreads laterally and begins to dissolve into groundwater, thereby forming the dissolved-phase plume (Figure 4-1(5)). Typically, dissolved-phase plumes attenuate via biological processes over short distances (e.g., a few hundred feet) (Wiedemeier et al., 1999). Over extended periods of time, the most soluble compounds weather out of the product, leaving behind a

mixture of low-solubility compounds that collectively have a relatively high viscosity. The viscosity of product samples taken from the site is very high (Table 4-2) compared with values typical of diesel and bunker C fuel oil.

The soil medium within which product exists is physically described as a porous medium consisting of solids (e.g., soil grains) and void space (soil pores). The void spaces in soil contain water (Figure 4-1(1)). Above the water table (vadose zone) air coexists with water in the pore space. Water is preferentially attracted to the solid surfaces, forms a continuous wetting phase about the soil grains, and fills the smaller pore spaces. Thus, water occupies the margins of the pore space, leaving the remaining central portions filled with air (a non-wetting fluid).

Released product flows downward through the vadose zone as a non-wetting phase that partially displaces air between soil particles (Figure 4-1(3)). Water remains on the particles as a continuous wetting phase. If the release is of sufficient volume (as was the case at the Skykomish site), the product will reach the groundwater table. Here, the free product displaces water from the interior regions of the soil void or pore space (Figure 4-1(4)). Selective entry of free product into larger pores reflects the fact that it is physically easier for free product to displace water from large pores than smaller pores.

Initially, product occurs in the smear zone as a continuous network of interconnected pores that contain product (Figure 4-1(4)). The product is surrounded by water that forms a continuous liquid phase about the solids. Product does not float above groundwater as suggested by the analogy of oil floating on water in a tank. Instead, product is largely submerged and its movement is constrained by the pressures needed to displace water from the pores at the margins.

Water and product coexist in the pores under different pressures. The difference in pressure between the product (non-wetting phase) and water (wetting phase) is defined as capillary pressure. Capillary pressure is a result of the two liquids (water and product) having different densities. This property governs the distribution and potential mobility of product in groundwater. The greater the pressure in the non-wetting phase (e.g., LNAPL), the more fully the pore space is filled (saturated) by the non-wetting phase.

The fraction of pore space occupied by product decreases over time as the volume of product is depleted. Depletion occurs from the volumetric movement of free product in the direction of groundwater flow and attenuation processes such as dissolution. With depletion, free product flow paths become smaller and more tortuous. This reduces the ease with which free product can move (mobility). Ultimately, the free product then breaks into isolated blobs and ganglia that are discontinuous and immobile as a

separate liquid phase (Figure 4-1(6)). The saturation or concentration at which product is immobile is referred to as residual saturation.

Residual product is present wherever free product has come into contact with soil. Thus, source areas where releases occurred and areas in the path of free product migration contain residual product. Residual product is “trapped” in the soil pores by capillary pressures and will not flow under the influence of gravity or groundwater flow.

Residual product is immobile but may remain a source of dissolved contaminants in groundwater. In the smear zone, soluble fractions of petroleum are dissolved and mobilized from the residual product until an insoluble residue remains. This is different than residual product left in the vadose zone that will not move under the force of gravity. Residual product in the vadose zone is also subject to dissolution, but because the smear zone is below the groundwater table some of the time, the dissolution is likely to be greater within the smear zone.

The threshold at which product becomes mobile (free product) is called the residual saturation concentration. This concentration depends on the physical properties of the product and the soil. A site-specific determination of residual saturation concentration is not available. MTCA provides a default assumption of 2,000 mg/kg for residual saturation of diesel and fuel oils, but the literature and site-specific conditions suggest that the residual saturation for diesel and fuel oil at this site is substantially higher and may exceed 10,000 mg/kg. For example, soil TPH concentrations in excess of 30,000 mg/kg are found adjacent to monitoring wells that contain no free-phase LNAPL (see Section 3). The site-specific MTCA residual saturation value (2,000 mg/Kg) is not appropriate for this site.

#### **4.2.4 Influence of the Barrier Wall on Free Product**

The barrier wall constructed parallel to the Skykomish River in August 2001 was part of an interim action to block free product from entering the river. The barrier wall extends from near the ground surface (above the water table) to below the seasonal groundwater table. The free product, which tends to move with groundwater, is thereby prevented from moving further downgradient towards the river and is collected in recovery wells. Seeps observed since the barrier wall construction are attributable to free product that existed between the barrier wall alignment and the river before construction.

The barrier wall was constructed to allow groundwater to flow around and beneath the wall, but prevent downgradient movement of free product. In the absence of product removal, mobile free product is expected to accumulate behind the barrier wall.

Groundwater generally flows in a northwesterly direction along most of the barrier wall. Groundwater elevation and flow direction near the wall have been largely unaffected by the barrier wall. Therefore, mobile free-phase LNAPL should continue to migrate toward the wall and recovery wells.

#### **4.2.5 Dissolved Petroleum Hydrocarbons Groundwater**

Both residual and free product are sources of groundwater contamination at the site. Individual chemical constituents of product dissolve into the passing groundwater in accordance with chemical and physical properties of the product and soil at this site. In the absence of natural degradation, these properties control the distribution of TPH constituents dissolved in groundwater. Once released into groundwater, the dissolved TPH constituents are subject to natural attenuation, such as resorption to soil particles, volatilization, dispersion, dissolution and biodegradation.

The data show that dissolved-phase TPH in groundwater is distributed very similarly to TPH in soil. The data also show that dissolved contaminants in groundwater attenuate rapidly with distance from free product and residual LNAPL in soil. This is consistent with the generally accepted understanding of petroleum LNAPL dissolution and attenuation as reported in the literature.

### **4.3 Conceptual Model Summary**

Figure 4-2 provides a physical conceptualization of impacts to the site. The figure summarizes and integrates existing knowledge of site geology, hydrogeology and contaminant distribution as previously discussed in this and previous sections of the FS/EIS. The figure is a cross section of the town from the Old Cascade Highway south of the railyard to the river north of the railyard. The geology is generalized based on information from boring logs. The seasonal high and low groundwater table defines the region labeled as the “smear zone.”

Petroleum releases in former maintenance and fueling areas at the site deposited fuel (product) on the ground surface. The product migrated vertically downward into the subsurface under the influence of gravity. While a portion of the product accumulated within soil pores above the groundwater table (vadose zone) and ceased moving (residual), the releases were of sufficient volume to migrate to the water table. Further vertical movement of product through the water table was precluded by the density differential between water and the product. Consequently, the free product spread in the upper horizon of the water table both laterally and in the direction of groundwater flow. Over time and under the influence of the prevailing hydraulic gradient, free product migrated in a north to northwesterly direction beyond the railyard boundary to the Skykomish River where seeps of free

product are currently observed. These seeps resulted in sediment impacts near the south embankment of the Skykomish River where groundwater recharges the river.

Residual hydrocarbon contamination in the vadose zone is restricted to the railyard where petroleum fuel was originally released and migrated from the surface vertically to the groundwater table. Free product is mainly found downgradient of the railyard, where it has migrated towards the river under the influence of groundwater flow. Groundwater in contact with free and residual product in soil becomes contaminated by dissolution of hydrocarbon constituents into the dissolved phase. The plume of dissolved-phase hydrocarbon contamination migrates downgradient, eventually entering the river and impacting surface water and sediment quality. Data indicate that the dissolved hydrocarbon plume attenuates rapidly with increasing distance from areas of free and residual product in soil and that removing free product from the soil and groundwater will protect surface water. Subsurface soil underlying the former Maloney Creek channel are composed of sand and gravel, generally overlain by a thin layer of silt. The former Maloney Creek channel area consists of a deeper smear zone continually hydrologically connected to surrounding soils to the north and south of the wetland, and a shallower zone with intermittent hydrologic contact with the surrounding soil. The deeper sand and gravel is contaminated with high concentrations of TPH, however, the biologically active portion of sediments within the wetland (upper 10 cm) is largely unaffected except during very high groundwater conditions. These sporadic, high groundwater events may introduce contaminants from underlying smear zone soil into shallow wetland sediment, but if this does occur it appears to result in concentrations <500 mg/kg in the biologically active zone.

Downstream bedload transport of sediment occurs during periods of heavy surface runoff. At these times, contaminated sediment may be mobilized and trapped upstream of the culvert. This is the likely source of the contamination noted in the surface sediment in this area. Sediment trapped here has filled in an old plunge pool. The decreasing concentrations at depth in older, deeper sediment suggest that the hydrocarbon contamination degrades or dissociates from the sediments over time.. Discharges from the period of railyard operations when oily contamination was evident in the channel are no longer present in the former Maloney Creek channel or its associated wetlands.

## **4.4 Exposure Assessment**

This section identifies potential human and ecological exposures to contaminated media at the site. Consistent with the purpose of the RI/FS (WAC 173-340-350(1)), the goal of this section is to identify exposure scenarios to assist in the selection of a cleanup action. Cleanup actions developed in this FS/EIS must “protect human health and the environment

(including, as appropriate, aquatic and terrestrial ecological receptors)” (WAC 173-340-350(8)(c)(i)(A)). In order to evaluate cleanup actions, the cleanup standards must be determined. As outlined in WAC 173-340-700(5), in order to set the cleanup standards applicable to cleanup actions, the following issues must be determined:

- Nature of the contamination
- Potentially contaminated media
- Current and potential land and resource uses
- Current and potential receptors
- Current and potential pathways of exposure

The nature of contamination and impacted media were described previously in Section 3. This section determines current and potential receptors and pathways of exposure, based on current and potential land and resource uses. Figure 4-3 is a conceptual site model illustrating potential exposure pathways present at the site.

#### **4.4.1 Current and Potential Land and Resource Uses**

Cleanup levels must derive from reasonable maximum exposures, defined as the “highest exposure that is reasonably expected to occur at a site under current and potential future site use” (WAC 173-340-708(3)(b)). This section identifies the current and future potential uses of resources where contaminated media are known or suspected to be present. The resources under consideration here are land, groundwater, surface water and sediment. The land resource may be divided into railyard and off-railyard areas.

##### **4.4.1.1 Railyard**

The railyard property is currently zoned industrial. This zoning designation (King County) is in accordance with land use planning under chapter 36.70A of the RCW (Growth Management Act). The railyard is currently used as industrial property by BNSF, and the most likely future use of the property is industrial. Trespassing is prohibited on the railyard and the general public is only permitted to cross the yard using the public right-of-way (Fifth Avenue). In response to the community’s request, BNSF recently installed a fence along the former Maloney Creek to reduce trespassing from the residential areas south of the yard. The BNSF railyard property is “industrial property” for purposes of GMA and MTCA (RCW 70.105D.030(2)(f) and WAC 173-340-200).

##### **4.4.1.2 Off-Railyard – Developed Property**

The current land uses of impacted off-railyard properties are residential, commercial (restaurants, hotels, stores), municipal (town offices and garages), and educational (Skykomish School). Some of the properties (notably the

town garages) may meet the requirements for designation as industrial property. However, for the purposes of this exposure assessment, the highest beneficial use of the developed properties off of the railyard is assumed to be residential. In addition to human health, ecological receptors must be protected as part of cleanup actions.

#### 4.4.1.3 Off-Railyard – Undeveloped Property

Undeveloped property exists to the south of the railyard along sections of the former Maloney Creek channel and along the south bank of the Skykomish River. These areas of undeveloped property are generally wooded. The narrow strip along the Skykomish River serves as part of the King County Department of Natural Resources flood-control dike for the Skykomish River. Future development in this area is unlikely.

A portion of the former Maloney Creek channel and surrounding wooded areas exist off railyard property. There are no known development plans for this area, and due to the proximity of this land to the railyard and other residences, no development is foreseen. However, the highest potential land use for these areas remains residential.

As these areas currently are vegetated with non-cultivated plants, and may support animal life, they are potential habitat for ecological receptors as discussed in Section 2.

#### 4.4.1.4 Groundwater

Groundwater contaminated with TPH and PAHs exists under the railyard and both developed and undeveloped off-railyard properties. Generally, the highest beneficial use of groundwater is as a source of drinking water (WAC 173-340-720(1)(a)). However, shallow groundwater in the impacted area of the Skykomish site is not a current source of potable water in Skykomish, nor will it likely be used as a source of potable water in the future.

WAC 173-340-720(2) sets forth criteria for determining whether the highest beneficial use of groundwater is potable water. Of these criteria, two are met at this site.

- ***The groundwater does not serve as a current source of drinking water – WAC 173-340-720(2)(a).***

Shallow groundwater is not currently used as a source of potable water in Skykomish. The public water supply wells for the Town of Skykomish are located approximately 0.5 mile upgradient of historic site operations and are screened about 200 feet bgs in fractured rock, presumably at the surface of the bedrock layer underlying the uppermost alluvial aquifer.

- ***The department determines it is unlikely that hazardous substances will be transported from the contaminated groundwater to groundwater that is a current or potential future source of drinking water at concentrations that exceed groundwater quality criteria WAC 173-340-720(2)(c), WAC 173-200).***

As stated above, current drinking water wells for Skykomish are located upgradient of the impacted groundwater plume. Based on gauging performed over at least 10 years, groundwater flow in the upper aquifer underlying the site is consistently toward the Skykomish River. Locally reversed gradients along the shoreline were observed during two pre-RI gauging events (October 1990 and December 1991). This is most likely due to transient increases in water levels in the river; the reversed gradient extended only slightly into the residential area near the river – approximately 100 to 150 feet. Further, based upon our knowledge of groundwater flow in river basins, it is correct to assume that groundwater flows toward the river.

In addition, the drinking water wells are screened to approximately 200 feet bgs. Five deep (35 to 40 feet bgs) monitoring wells have been installed at the site; none of these have ever had detectable levels of TPH. Well DW-5, located near the recovery system and screened below the LNAPL layer, has been sampled 10 times between 1993 and 1997; TPH has never been detected. Based on this data, the plume of dissolved TPH attenuates within a short distance (less than 25 feet) below the LNAPL plume. Therefore, because the drinking water wells are located upgradient of site impacts and are screened much deeper than any known groundwater contamination beneath or downgradient of the site, it is impossible that hazardous substances in groundwater underlying the site would be transported to the vicinity of the public water supply wells.

WAC 173-160-171(3) provides an additional regulatory requirement that makes the use of groundwater in the vicinity of the Skykomish site unlikely. WAC 173-160-171(3) requires that wells shall not be located within certain minimum distances of known or potential sources of contamination, including septic systems. The minimum setback specified in WAC 173-160-171(3)(b) is 50 feet from a septic tank, septic holding tank, septic containment vessel, septic pump chamber, and septic distribution box and 100 feet from the edge of a drain field. It is estimated that the commercial and residential portions of the site all meet this criteria, as the town uses septic systems for wastewater management. These regulatory requirements, along with the availability of public water supply, make use of shallow groundwater in the vicinity of the site as a potential source of drinking water highly improbable.

Other potential users of groundwater are industry, businesses and agriculture. In order to extract groundwater for these uses, groundwater wells are required. There are no known existing groundwater extraction wells for agriculture in Skykomish, nor are there industrial processes with high water demand which may desire groundwater extraction to support these processes. Siting for wells to be used for industrial, commercial, and agricultural is also required to meet the setback requirements in WAC 173-160-171(3). As such, there is no current or reasonable potential future human use of groundwater in Skykomish. However, since the criterion listed in WAC 173-340-720(2)(b) is not applicable to the site, it cannot be determined that groundwater is not a potential future source of drinking water.

Despite the unlikelihood of human use of groundwater in Skykomish, cleanup actions for groundwater in Skykomish must prevent direct or indirect violations of surface water, sediment, soil, or air cleanup standards (WAC 173-340-720(1)(c)). As groundwater discharges to the Skykomish River and, at times, to the former Maloney Creek channel, highest beneficial use of these water bodies must be protected; that is, groundwater must be protected as a potable water source.

#### **4.4.1.5 Surface Water**

WAC 173-340-730(1)(a) states that cleanup standards for surface water (Skykomish River and Maloney Creek) are “based on estimates of highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions.” WAC 173-201A defines the Skykomish River as a Class AA river. Characteristic uses of Class AA rivers include water supply (domestic, industrial, agricultural), stock watering, fish and shellfish, wildlife habitat, recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment), commerce and navigation. As discussed above, the water supply for Skykomish comes from wells upgradient of the town, not from the Skykomish River. However, this does not preclude downstream use of the river for any of these purposes.

### **4.4.2 Potential Receptors**

For the purposes of this exposure assessment, receptors and receptor activities are identified based on the highest beneficial use of each resource, as required in WAC 173-340-708(3)(b). This section discusses receptors that may be present at the site, based on the beneficial uses identified in the previous section, and observed land and water uses in the Skykomish area.

#### **4.4.2.1 Residents**

The highest beneficial use of the railyard is industrial. However, trespassers have been observed on the railyard and have the potential to contact surface soil. Trespassers are assumed to reside on the railyard only briefly (in transit

across the railyard) and are typically not frequenting areas where access is limited by fencing.

Residential use is the highest beneficial use of property off the railyard. Current and future residents of the Town of Skykomish may garden or landscape in the surface soil (i.e., off railyard property), and may have basements that extend into the impacted subsurface soil. Residents do not typically excavate to subsurface soil.

#### **4.4.2.2 Industrial Railyard Workers**

Industrial railyard workers are typically not engaged in construction work that would involve excavation on the railyard. However, these workers may directly contact surface soil during day-to-day maintenance activities.

#### **4.4.2.3 Construction and Utility Workers**

Construction and utility workers engaged in excavation work on or off the railyard have the potential for exposure to surface soil, subsurface soil, and groundwater.

#### **4.4.2.4 Recreational Users of the Skykomish River**

Humans use the Skykomish River for recreational purposes, such as rafting, kayaking, fishing, and boating. Thus, the potential exists for human receptors to contact contaminated surface water and sediments of the Skykomish River, and to ingest fish from the river.

#### **4.4.2.5 Terrestrial Ecological Receptors**

Under WAC 173-340-7490(2), a terrestrial ecological evaluation must be performed unless conditions allowing exclusion of such evaluation are met. Ecology has determined that a site-specific terrestrial ecological evaluation must be performed. A terrestrial ecological evaluation is in progress, and a screening level literature review will be submitted under separate cover. If it is determined that site-specific cleanup levels must be developed to protect terrestrial organisms, it is anticipated that would require 6-8 months. BNSF continues to dispute that a terrestrial ecological evaluation is needed for this site. The existing residential areas of Skykomish are not “contiguous undeveloped land” under WAC 173-340-7490(1)(c)(ii).

#### **4.4.2.6 Ecological Receptors in the Skykomish River**

The Skykomish River is habitat for fish, shellfish, and sediment-dwelling organisms, as discussed in Section 2.2.6. These are the most sensitive users of the surface waters near the site. Other potential downstream receptors (e.g., water users) encounter very low contaminant concentrations, due to the dilution that occurs within the river. Downstream receptors typically involve larger organisms (i.e., livestock), which tend to be less sensitive to low-level

contaminant exposures. Cleanup actions to protect in-stream organisms will protect downstream water users.

#### **4.4.2.7 Ecological Receptors in Former Maloney Creek Channel/ Wetlands**

Ecological receptors in wetlands are present in and around the former Maloney Creek channel. Fish use the wetland and ditches connected to the wetland. The wetland characteristics, habitat and potential ecological receptors are characterized in Section 2.2.6 and Appendix C.

The same assumptions cited above for the Skykomish River apply to the former Maloney Creek channel. The ecological receptors in the creek are considered the most sensitive receptors, and scenarios evaluating these receptors will adequately address potential impacts to other downstream receptors.

### **4.4.3 Transport Mechanisms**

Figure 4-3 depicts the mechanisms (shown with purple arrows) by which contaminants (summarized in Section 4.2) can be transported and thereby lead to a potential exposure to the receptors described in Section 4.4.2. These mechanisms are summarized below.

#### **4.4.3.1 Surface Soil to Water**

Contaminants in surface soil may be mobilized (dissolved or sorbed to soil particles) by stormwater. The stormwater may then infiltrate to groundwater, or may travel over the surface, generally to storm drains, which in turn, lead to the Skykomish River.

#### **4.4.3.2 Free Product to Water**

Free product moves in the direction of groundwater flow under potentiometric forces (i.e., hydraulic gradient). Contaminants enter the dissolved phase of groundwater after leaching from soil or free product or following infiltration of contaminated stormwater. The dissolved phase contaminants are then transported with the movement of groundwater. Groundwater at the site moves toward, and discharges to, the Skykomish River.

#### **4.4.3.3 Soil, Groundwater, and Free Product to Indoor Air**

Contaminants sorbed to surface soil (e.g., on the railyard) can be transported by wind. Wind-blown transport of lead and arsenic from soil to air is a complete exposure pathway, and will be evaluated further in this document. As shown on Figure 4-3 and discussed in Section 3.6, volatilized contaminants may be present in ambient air or may accumulate in confined spaces. See Section 2.4.3 regarding interim actions being taken by BNSF to control dust.

#### **4.4.4 Potential Receptor Exposures**

This section discusses the potential for receptors to encounter IHSs via one of the exposure or transport mechanisms identified previously. Figure 4-3 depicts these potential receptor exposures (highlighted in green).

##### **4.4.4.1 Industrial Worker Exposures (on Railyard)**

Routine railyard industrial workers are typically engaged in maintenance work and have the potential for contact with contaminated surface soil on the railyard. Direct contact, inhalation and incidental ingestion are the potential means of industrial worker contact with surface soil. Exposure to volatilized contaminants in outdoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Railyard industrial workers are unlikely to be involved in excavation work that could lead to contaminated subsurface soil and groundwater exposures. Further, exposure to contaminated storm water flow is considered a negligible exposure pathway.

##### **4.4.4.2 Construction and Utility Worker Exposures (On and Off Railyard)**

Construction and utility workers may be exposed to contaminated surface soil, subsurface soil and groundwater while excavating. Direct contact, inhalation and incidental ingestion are the potential means of worker contact with these contaminated media. Exposure to volatilized contaminants in outdoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Exposure to contaminated stormwater flow is considered a negligible exposure pathway.

##### **4.4.4.3 Residential Exposures**

Residents of the Town of Skykomish may contact contaminated surface soil off the railyard via direct contact or inhalation of soil transported off the railyard by wind. Exposure to volatilized contaminants in indoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Residents who enter the railyard (trespassers) and come into contact with surface soil have the potential for occasional and very minor short-term exposures to surface soils. Residents who conduct redevelopment work on their homes may be exposed to contaminated subsurface soils, groundwater, vapors and free petroleum product. However, deep excavation work is typically contracted out to commercial workers.

##### **4.4.4.4 Terrestrial/Ecological Exposures**

Terrestrial receptors have the potential for exposure to contaminated groundwater at the riverbank, where groundwater discharges to the Skykomish River. Deep roots of plants or terrestrial receptors drinking water

near the potential groundwater discharge locations in the Skykomish River or former Maloney Creek channel may ingest groundwater.

Groundwater may recharge the former Maloney Creek channel during prolonged periods of heavy precipitation coupled with a rise in groundwater table. During these conditions, aquatic organisms have the potential to come into contact with contaminated groundwater.

#### **4.4.4.5 Recreational User Exposures**

Recreational users of the Skykomish River have the potential to come into contact with contaminated groundwater and free product at the riverbank (direct contact and incidental ingestion) where groundwater discharges to the Skykomish River. Further, recreational users of the river may contact surface water that has been impacted by contaminated groundwater (and free product LNAPL) discharges to the river. Exposure to contaminated surface water further away from the riverbank is a minor risk as the fast-moving surface water flow quickly dilutes the upland discharges to inconsequential contaminant concentrations.

### **4.5 Summary**

The information presented in this section serves as the foundation for development of cleanup standards and cleanup action alternatives under MTCA. As presented in Section 5, cleanup levels are developed for the IHSs based on their potential for migration to other media and for exposure to various human and ecological receptors.

Figure 4-3 illustrates the complete human and ecological conceptual site model. This figure illustrates how the IHSs can potentially affect human health and ecology by migrating through soil, stormwater, groundwater, and surface water to potential receptors. In summary, complete exposure pathways are summarized in the following sections by media. They are summarized by media because cleanup levels are developed for each receptor by media in Section 5.1. The cleanup actions that will mitigate these exposure pathways are described in the following sections of this report.

#### **4.5.1 Soil**

The following human populations have the potential for exposure to soil:

- Industrial Worker (on railyard) to surface soil
- Construction and Utility Workers (on and off the railyard) to surface and subsurface soil
- Residents (on railyard) to surface soil

- Residents to subsurface soils (off the railyard while excavating)
- Residents (on and off railyard) through the soil to outdoor air transport mechanism

In addition,

- Terrestrial receptors have the potential for exposure to soil.
- IHSs in soil can migrate to groundwater; therefore, cleanup levels are developed in Section 5 for concentrations of soil that protect groundwater.

As such, in Section 5, cleanup levels are developed for human health, ecology, and soil concentrations that protect groundwater.

#### **4.5.2 Groundwater**

The following summarize potential receptors to IHSs in groundwater:

- Construction and Utility Workers (on and off the railyard to groundwater while excavating)
- Residents (off the railyard to groundwater while excavating)
- Receptors to sediment due to the transport mechanism of groundwater to sediment
- Aquatic receptors to surface water due to the transport mechanism of groundwater to surface water
- Recreational users of the Skykomish River and Maloney Creek due to the transport mechanism of groundwater to surface water

As such, in Section 5, cleanup levels are developed for human health, groundwater concentrations that protect sediment, and groundwater concentrations that protect surface water.

#### **4.5.3 Sediment**

The potential receptors to IHSs in sediments are biota that dwell in, and feed on and from, the sediment.

#### **4.5.4 Surface Water**

No IHSs other than TPH have been detected in surface water; however, surface water (specifically Skykomish River and Maloney Creek) directly affects recreational, terrestrial, and aquatic receptors. To ensure that the

health of these receptors is protected, groundwater IHSs are used to calculate cleanup levels for these receptors.

Cleanup levels are developed for human health and ecological receptors in Section 5.